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Joachim Schulz et al
Sr. No. 10/017,089
Conf. No. 6522
Filed December 15, 2001
LASER BEAM REFORMING SYSTEM

Group Art Unit 2881
Examiner Flores

Transmittal of Translation
Copy of Translation of German Offenlegungsschrift 4421600

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

JOACHIM SCHULZ ET AL

Serial No. 10/017,089
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Examiner Flores

LASER BEAM REFORMING SYSTEM

June 17, 2003

Commissioner for Patents
PO Box 1450
Alexandria, Virginia 22313

Sir:

TRANSMITTAL OF TRANSLATION

As requested by Examiner Flores, Applicants' counsel has obtained and enclose herewith a translation of the detailed portion of the specification of German Offenlegungsschrift 44 21 600.

Respectfully submitted,

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Fig. 1 is a cross section of a coaxial laser with the device in the invention.

Figs. 2 and 3 show the shape of the beam cross section and the polarization direction within the beam cross section for a laser beam before or after it goes through the laser beam-forming device in the invention.

Fig. 4 is an axial top section of the laser beam-forming device.

Figs. 5 and 6 is a section of an ideal arrangement of the mirrors inside the laser beam-forming device that can be made in practice and an arrangement in terms of the figure requirements.

Figs. 7 to 10 show other embodiments of the laser beam-forming device in the invention.

Fig. 11 discloses a preferred embodiment of the coaxial laser in the invention, in which the laser beam-forming device is arranged inside a resonator of the laser.

According to Fig. 1, a coaxial laser, for example a coaxial waveguide laser, contains hollow cylindrical electrodes 2 and 4 arranged coaxially to one another that delineate a hollow-cylindrical discharge space 10. Opposite one of the front surfaces of the hollow cylindrical electrodes 2 and 4 is a first resonator mirror 6, and opposite the other front surface a second resonator mirror 8 is arranged. The first resonator mirror 6 is designed on part of its circumference, for example, half its circumference, as a partly transparent mirror 6a and on the other part as a non-transparent mirror 6b. The resonator mirrors 6 and 8 form a resonator, along with the coaxial waveguide formed by electrodes 2 and 4. The laser beam 12 coming through the partly transparent mirror 6a and coming out of the resonator has a cross section that is also annular-sector-shaped corresponding to the annular-sector-shaped design of the partly transparent mirror 6a.

The resonator mirror 8 is preferably designed as a conical mirror or, as shown in the figure, as a rotation paraboloid, in order to effectively couple all areas of the resonator.

Opposite the partly transparent mirror 6a in the direction in which the laser beam 12 propagates is a first mirror 20 whose surface is shaped like a conical sector on the conical axis 30. The axis of the laser beam 12 is parallel to this conical axis 30. This first mirror 20 defects the laser beam 12 coming out of the resonator by an angle α close to 90°. The angle α corresponds to the angle of aperture of the cone sector. A

small angle deviation of 90° is necessary to allow the laser beam 12 to be uncoupled, and should be chosen as small as possible within the context of the predetermined geometric conditions.

The laser beam 14 deflected by the first mirror 20 hits a second mirror 24, whose surface has the shaped like a parabolic cylinder, whose line focus coincides with the conical axis 30 of the first mirror. The laser beam 16 reflected by this second mirror 24 then has an approximately rectangular cross section with constant linear polarization over the cross section.

Fig. 2 shows the cross section of the laser beam 12 coming out of the resonator and the polarization directions 13 for the different areas within this beam cross section. In the figure, it can be seen that the polarization direction 13 runs at a tangent and thus varies within the cross section of the beam.

Compared to one shown in Fig. 3, the laser beam 16 reflected by the second mirror 24 has an approximately rectangular cross section with a polarization direction 17 that is constant over the whole cross section. The laser beam 16 reflected by the second mirror 24 also has these properties if the laser beam coming out of the resonator has a radial polarization.

The top view in Fig. 4 shows that the conical axis 30 coincides with the line focus of the convex second mirror 24. This way, the beams 14 focused by the first mirror 20 as a line on the conical axis 30 are transformed into beams 16 parallel to one another.

Precisely converting an annular-sector-shaped beam cross section into a rectangular beam cross section is only strictly theoretical with the mirror arrangement in Fig. 5, which contains a first mirror 21 whose conical angle of aperture is exactly 90°. This mirror 21 produces a deflection of the laser beam 12 by exactly 90°, which makes it very difficult for the laser beam to come out of the laser for structural reasons.

For this reason, in the practical example of embodiment, the conical angle of aperture of the first mirror 20 deviates roughly 90°. It can be seen in the cross section in Figure 6 that the deflection of the laser beam 12 on the first mirror 20 takes place at an angle α, which deviates by a small angle 8 from 90°. In the example in the figure, 5 is negative, i.e., the angle α is less than 90°. But the angle α can also be greater than 90°. This 90° deviation is necessary to make it possible for the laser beam 16 reflected on the second mirror 24 to be able to come out of the resonator. The result is that the cross section of the laser beam 16 reflected in the second mirror 24 has only approximately the shape of a square. The disadvantages of this can be taken into account, however, for small angles 8 up to roughly 20°.

Instead of a conical angle of aperture deviating by 90°, the mirror 24 can also be tipped so that the line focus and conical axis no longer coincide exactly and the laser beam 16 can come out that way.

Figures 7 and 8 show another embodiment of a device suitable for forming the beam in the invention. This embodiment has a second mirror 26 with a concave curvature. In this example, the conical axis 30 also coincides with the line of focus of the second mirror 26, which lies outside the second mirror 26 in this case.

In the embodiment in Figures 9 and 10, there is a first mirror 22, whose reflecting surface is formed by a cutout that is less than 180°. The size of the cutout must be adjusted in all embodiments to the size of the laser beam 12 coming out of the resonator in such a way that the whole laser beam 12 is formed. Fig. 10 also shows that the conical angle of aperture, and hence angle α is also less than 90°.

In the example of embodiment in Fig. 11, the beam-forming device made up of a first mirror (conical mirror) 22 and a second mirror (parabolic cylinder mirror) 24 is arranged in a resonator bounded by mirrors 8, 7a and 7b. This mirror 8, like the example of embodiment in Fig. 1, is preferably a parabolic or conical mirror. Mirror 7b, preferably a toroid on a coaxial waveguide laser, covers only part of the front of the discharge space 10 facing it, so that a laser beam with an annular sector-shaped cross section reaches the first mirror 22 of the beam-forming device and from there is deflected to the second mirror 24. The beam 16 reflected from the second mirror 24 with a rectangular cross section hits a partly transparent mirror 7a, for example a plane mirror, especially a cylinder mirror, which lets through part of the beam 16, and part is again reflected into the laser beam-forming device. There, the beam reflected back is transformed into a laser beam with an annular-sector shaped cross section and goes back into the waveguide. A flat deflection mirror 29 is also arranged in the path of the propagating laser beam 16 in one preferred embodiment and aligns the beam 16 parallel to the longitudinal axis of the laser.